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ON STRUCTURE DEFECTS IN SILICON SINGLE CRYSTALS INTRODUCED BY FAST ELECTRON AND NEUTRON IRRADIATION

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(Abstract)

Silicon single crystals are of interest as an object for the investigation both of the primary process of atoms displacement and the introduction of Frenkel pairs by irradiation, and also of the subsequent interaction of vacancies and interstitial atoms with chemical impurities and the energy levels of the resulting local imperfection centers.

The investigation of the photoconductivity in the impurity spectral range at low temperatures, combined with Hall effect measurements gave us a possibility of a further understanding of energy levels spectrum and other properties of centers introduced into silicon by electron and neutron irradiation and having complex nature as compared with partners of a Frenkel pair. The analysis of the photoconductivity spectra makes it possible to resolve the structure of the deep energy levels systems when other methods, for instance Hall effect or recombination rate measurements only indicate the presence of deep levels. At present, the energy levels system resulting from radiation induced imperfections in silicon includes the data of the table 1.

According to our results the photoconductivity spectra of identical silicon samples irradiated by electrons and neutrons practically coincide, which indicates the absence of group effects playing probably an important part in case of germanium.

Experiments with crystals bombarded by electrons at 100°K show that the final discrete photoconductivity spectrum is a result of the defects or impurities thermally activated migration. At the initial stage after the low temperature bombardment no structure in the photoconductivity spectrum is visible.

The parallel investigation of the annealing of photoconductivity and Hall effect in irradiated silicon gave us a possibility to correlate the optical and thermal ionisation energies for some of the energy levels of the defects.

The irradiation of silicon samples containing lithium and copper shows that the interaction of the defects with these impurities strongly affects the stability of defects and the introduction rates of energy levels. However, the system of radiation induced energy levels remains practically unchanged.

The results were obtained in collaboration with A.F.Plotnikov, G.N.Galkin, V.M.Malovetskaja and I.V.Smirnova.

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Table 1

Energy level position	$E_c - 0,03ev$	$E_c - 0,16ev$	$E_c - 0,21ev$	$E_c - 0,4ev$	Middle of forbidden gap	$E_v + 0,45ev$	$E_v + 0,38ev$	$E_v + 0,35ev$	$E_v + 0,3ev$ (0,27)	$E_v + 0,05ev$	
The nature of defect or complex	Frenkel pair?	Association of vacancy and oxygen atom	Not determined	Association of vacancy with donor impurity atom	Not determined	Not determined	Not determined	Not determined	Association of defect (interstitial ? with oxygen atom	Frenkel pair?	
Experimental method	Capture of electrons	Hall Effect Recombination rate Photoconductivity	Infrared absorbtion	Hall Effect Spin electron resonance Photoconductivity	Recombination rate	Photoconductivity	Photoconductivity	Photoconductivity	Hall Effect Recombination rate Photoconductivity	Capture of holes	
Reference	1	3, 4, 5, 6, 7, 8	2	1, 6, 7	8	7	7	7	1, 2, 3 7, 8	1	

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